S
333.955
E30ais
2001

MONTANA STATE LIBRARY
3 0864 1001 7632 3

AN ASSESSMENT OF SPRING CREEK, TETON COUNTY: HABITAT AND AQUATIC INVERTEBRATE ASSEMBLAGES

August 2000

report prepared for

The Montana Department of Environmental Quality

Helena, Montana

by

Wease Bollman

Rhithron Biological Associates

Missoula, Montana

STATE DOCUMENTS COLLECTION
FEB 0 5 2003
MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

October, 2001

INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in August 2000 from two sites on Spring Creek, Teton County, Montana. Aquatic invertebrate assemblages were sampled by personnel of the Montana Department of Environmental Quality (DEQ). Study sites lie within the Montana Valleys and Foothill Prairies ecoregion (Woods et al. 1999). A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is " ...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics specific to that ecoregion, which has been shown to be sensitive to impairment, related to habitat assessment parameters and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

METHODS

Aquatic invertebrates were sampled at two sites by Montana DEQ personnel on August 1, 2000. Sample identifications are given, sites are described, and locations indicated in Table 1. The sampling method employed was that recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). In addition to aquatic invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998).

Table 1. Sampling sites. Two sites on Spring Creek. August, 2000.

Sample identifier	Site description	Site location
S 1 (upstream)	Unnamed road crossing downstream of US Hwy 89 crossing	47° 51' 57" N 112° 14' 27"W
S 3 (downstream)	Upstream of Choteau	47° 50' 05" N 112° 11' 41"W

Evaluated habitat features include instream conditions, larger-scale channel conditions including flow status, streambank condition, and extent of the riparian zone. Scores were assigned in the field to each habitat measure, and these scores were totaled and compared to the maximum possible score to give an overall assessment of habitat.

Aquatic invertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses. In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess macroinvertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998) was used. Choice of an assessment protocol was problematic for this study, since no protocol specific for spring streams and their unique biology has yet been developed. A tested multimetric index exists only for run-off dominated streams of western Montana ecoregions. Bioassessment scores are thus tentative, and may not reflect true conditions in Spring Creek. The extent of the influence of spring flow at the sites studied is not apparent from the data provided. The pertinence of the method used in this report depends on the extent to which flow from springs influences water quality and habitat at the study sites.

Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998). The multimetric index used in this

report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of Spring Creek results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. Still, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present in Spring Creek drainage. They have been demonstrated to be more variable with anthropogenic impairment than with natural environmental gradients (Bollman 1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and

when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* sp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. **Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of the Montana Valleys and Foothill Prairies ecoregion (Bollman 1998).

	score			
metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 - 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 - 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 - 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3a.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability

in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1997)

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989)

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

Habitat assessment

Figure 1 compares habitat assessment results for the two sites in this study. Table 4 itemizes the evaluated habitat parameters and shows the assigned scores for each.

Figure 1. Habitat assessment scores for two sites on Spring Creek. Scores are expressed as percent of maximum. Sites are described in Table 1.

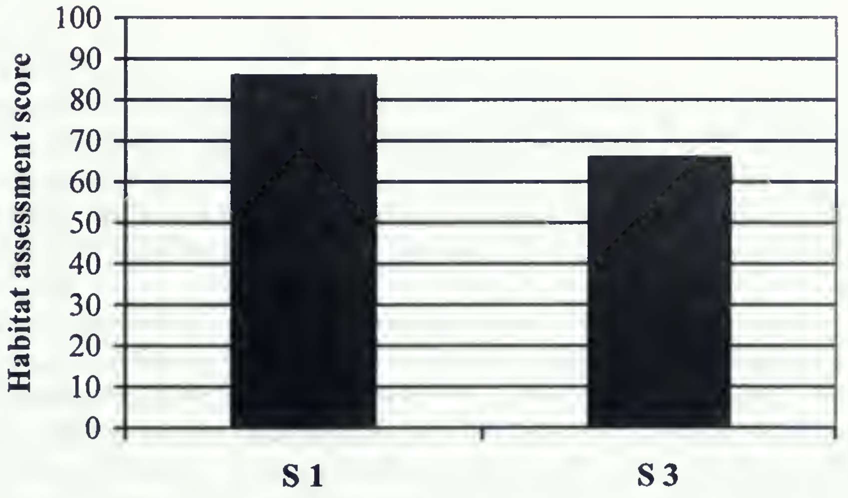

Table 4. Stream and riparian habitat assessment: Spring Creek, August 2000.

Maximum possible score	Location:	S 1	S 3
	Parameter		
10	Riffle development	9	6
10	Benthic substrate	9	2
20	Embeddedness	15	11
20	Channel alteration	19	12
20	Sediment deposition	19	9
20	Channel flow status	17	17
10 / 10	Bank stability (left/right)	9 / 9	8 / 8
10 / 10	Bank vegetation protection (left/right)	9 / 9	8 / 8
10 / 10	Riparian vegetation zone width (left/right)	7 / 7	8 / 8
160	TOTAL SCORE	138	105
	PERCENT OF MAXIMUM:	**86**	**66**
	CONDITION[1]	**Optimal**	**Sub-optimal**

[1]Optimal >81%, Sub-Optimal 75-56%, Marginal 49-29%, Poor <23%. Plafkin et al. 1989.

Habitat conditions at the upstream site on Spring Creek were judged optimal. Benthic substrate appeared to be a diverse mix of cobbles and pebbles, and macrophytes added complexity to habitat. Minimal fine sediment deposition and embeddedness were noted. Stable, well-vegetated streambanks were reported, and only minimal disturbance to the riparian zone was apparent.

The lower site on Spring Creek was judged to have sub-optimal habitat conditions. Monotonous substrate and moderate deposition of fine sediments appeared to limit available instream habitats. The field investigator reported that channel morphology was affected by over-widening and some downcutting. Mild streambank erosion was also noted at this site.

Bioassessment

Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix. Figure 2 summarizes bioassessment scores for aquatic invertebrate communities at the two Spring Creek sites in this study. Table 5 itemizes each contributing metric and shows individual metric scores for each site. Table 3a and 3b show criteria for impairment classifications and use-support categories recommended by Montana DEQ.

Bioassessment scores using this model indicate moderate impairment of biotic health at both sites on Spring Creek. Sites only partly support their designated uses. At both sites, the number of Plecoptera taxa was lower than expected. Neither site supported sensitive taxa. Ephemeroptera taxa richness was also somewhat lower than expected at both sites. At the upper site, the percent of the assemblage comprised of tolerant organisms was moderately high, and the proportion of filter-feeding organisms was higher than expected. At the upper site, the percent of the assemblage comprised of tolerant organisms was very high.

Figure 2. Total bioassessment scores for two sites on Spring Creek. Scores are expressed as percent of maximum possible score. Sites are described in Table 1.

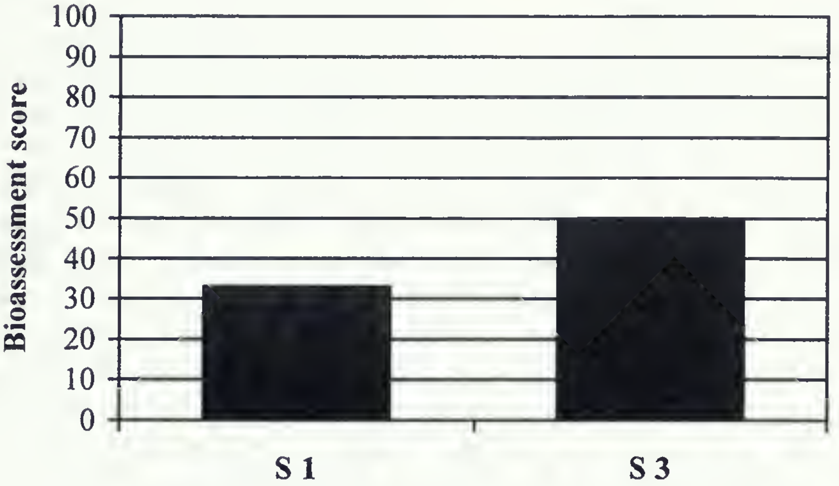

Table 5. Metric values and bioassessments for Spring Creek, August 2000.

	Sites	
	S 1	**S 3**
Metric		
Ephemeroptera richness	5	5
Plecoptera richness	1	1
Trichoptera richness	3	5
Sensitive taxa richness	0	0
Percent tolerant taxa	28	78
Percent filter-feeders	25	<1
	Metric scores	
Ephemeroptera richness	2	2
Plecoptera richness	1	1
Trichoptera richness	2	3
Sensitive taxa richness	0	0
Percent tolerant taxa	1	0
Percent filter-feeders	0	3
Total score (maximum = 18)	6	9
Percent of maximum	33	50
Use support*	**PART**	**PART**
Impairment classification[1]	**MOD**	**MOD**

1.Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

*Use support designations: See Table 3a.

Aquatic invertebrate communities

High biotic index values at both sites (6.06 at the upper site and 6.38 at the lower site) result from the preponderance of non-insect taxa in samples. Non-insects, such as the tubificid worm *Limnodrilus hoffmeisteri*, and the amphipods *Gammarus* sp. and *Hyalella azteca* comprised 35% of the sampled assemblage at the upstream site (S 1) and 39% of the assemblage taken at the lower site (S 3). These findings suggest that water quality may be compromised by nutrient and/or organic pollution, or that water temperatures may be moderately high for a foothill stream. Five mayfly taxa were collected at each site, however, so that mayfly richness was not severely compromised. The number of mayfly taxa has been shown to be positively correlated with water quality in streams of western Montana. At site S 1, however, three of the five mayfly taxa in the sample were in the tolerant family Baetidae. These were the ubiquitous *Baetis tricaudatus*, which is quite tolerant both of pollutants and of elevated temperatures, *Fallceon quilleri*, which is typically confined to warmer waters, and *Labiobaetis* sp. Two of these three baetids were also among the five mayfly taxa present at site S 3; the dominant taxon (25% of organisms) in the assemblage collected at that site was the mayfly *Caenis latipennis*, which, like *F. quilleri*, is characteristic of warm waters.

At site S 1, high taxa richness and high predator taxa richness suggest that instream habitats are plentiful and diverse. There are some suggestions that sediment deposition may compromise habitats to some extent, however, since the six "clinger" taxa collected at the site was somewhat fewer than expected, and the number of caddis fly taxa (3) as well as their abundance (4 individuals) was quite low. Suspended fine organic material appears to have been plentiful, since 25% of the organisms present in the sample were filter-feeders, including the blackfly *Simulium* sp. The dominant organism (16%) in the assemblage was the filter-feeding midge *Tanytarsus* sp.

The single stonefly taxa collected, *Amphinemura* sp., was also the only shredder present in the sample. Low stonefly richness suggests that reach-scale features, such as streambank integrity may be degraded, or that channel alteration may be affecting the benthic community. Warm water temperatures may also limit the stonefly fauna. The dearth of shredder taxa suggests that riparian inputs of large organic debris are not adequate to support this functional group, or that hydrologic conditions preclude retention of such material.

At the downstream site (S 3), tolerant taxa comprised 78% of the sampled organisms, strongly suggesting that impaired water quality was the dominant influence on the taxonomic composition of the benthic assemblage. Among the ten dominant taxa were two species of amphipods, *Hyalella azteca* and *Gammarus* sp., and the tolerant mayfly *Caenis latipennis*. Together, these three organisms comprised more than half of the animals collected at this site. Their abundance suggests that organic and/or nutrient pollution as well as warm temperatures may impair water quality here.

Low numbers of "clinger" taxa (6) at this site suggest that some instream habitat diminishment results from fine sediment deposition. While caddis fly taxa are more numerous here than at the upstream site, three of the five taxa collected were represented by only a single individual. Only a single filter-feeder, and immature hydropsychid caddis fly, was collected here, suggesting that suspended organic particles were scarce. Scraper taxa were considerably more abundant here than at the upper site, comprising 17% of the assemblage, and suggesting that site S 3 is less shaded than site S 1.

As at the upstream site, low numbers of Amphinemura sp. represented the only stonefly taxa collected, suggesting reach-scale disturbances, or warm water temperatures. Low numbers of shredders in three taxa were present at this site.

CONCLUSIONS

- Warm water temperatures and/or nutrient pollution seem to be indicated by the calculated biotic index values as well as by the taxonomic composition of the benthic assemblages collected at both sites on Spring Creek. The relative contribution of these factors is not clear.
- Mild-to-moderate sediment deposition appears to limit instream habitat at both sites.
- The relationship between habitat assessment scores and bioassessment scores suggests that water quality was a limiting factor to the biotic health of the benthic communities at both sites, though the effect of water quality on biotic health was more pronounced at the upstream site. Habitat degradation was present at the lower site, primarily in the form of monotonous substrates and sediment deposition, and this appeared to be the more influential factor on the benthic assemblages. Figure 3 illustrates this. Points representing the sites lie below a line describing the expected relationship between habitat and biotic health when water quality is unimpaired. The point representing the lower site is nearer to that line suggesting that habitat degradation was perhaps the more potent influence on biotic health at this site. For the upper site, bioassessment scores are much lower than would be expected if impairment was due to habitat degradation alone; this suggests that water quality impairment, perhaps by warm water temperatures or nutrient pollution, was the predominant factor limiting biotic health at this site.

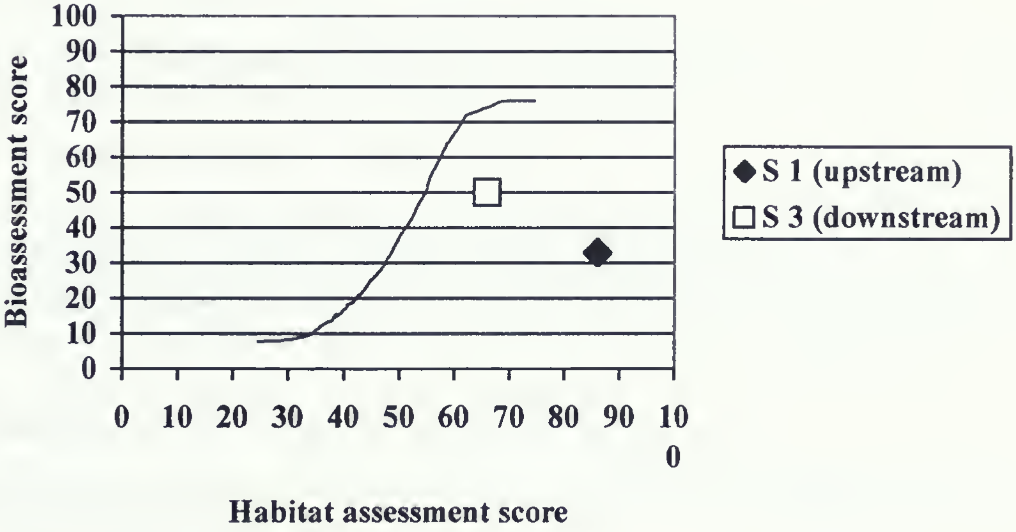

Figure 3. Total bioassessment scores plotted against habitat assessment scores for two sites on Spring Creek August 2000. The red line describes the hypothetical relationship expected when water quality is good and biotic health is determined predominantly by habitat quality (Barbour and Stribling 1991).

LITERATURE CITED

Barbour, M.T., J.B. Stribling and J.R. Karr. 1995. Multimetric approach for establishing biocriteria and measuring biological condition. Pages 63-79 in W.S. Davis and T.P. Simon (editors) *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making.* Lewis Publishers, Boca Raton.

Barbour, M.T. and J.B. Stribling. 1991. Use of habitat assessment in evaluating the biological integrity of stream communities. In: *Biological Criteria: Research and Regulation.* Proceedings of a Symposium, 12-13 December 1990, Arlington, Virginia. EPA-440-5-91-005. U.S. Environmental Protection Agency, Washington, DC.

Bollman, W. 1998. Improving Stream Bioassessment Methods for the Montana Valleys and Foothill Prairies Ecoregion. Unpublished Master's Thesis. University of Montana. Missoula, Montana.

Bollman, W. 2000. Bioassessment of Mizpah Creek, Powder River County, Montana. August-September 1999. Report to the Montana Department of Environmental Quality.

Bukantis, R. 1997. Rapid bioassessment macroinvertebrate protocols: Sampling and sample analysis SOP's. Working draft, April 22, 1997. Montana Department of Environmental Quality. Planning Prevention and Assistance Division. Helena, Montana.

Fore, L.S., J.R. Karr and L.L. Conquest. 1994. Statistical properties of an index of biological integrity used to evaluate water resources. *Canadian Journal of Fisheries and Aquatic Sciences.* 51: 1077-1087.

Fore, L.S., J.R. Karr and R.W. Wisseman. 1996. Assessing invertebrate responses to human activities: evaluating alternative approaches. *Journal of the North American Benthological Society* 15(2): 212-231.

Gauch, H. G. 1982. *Multivariate Analysis in Community Ecology.* Cambridge University Press. Cambridge.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. *Great Lakes Entomologist.* 20: 31-39.

Hynes, H.B.N. 1970. *The Ecology of Running Waters.* The University of Toronto Press. Toronto.

Kleindl, W.J. 1995. A benthic index of biotic integrity for Puget Sound Lowland Streams, Washington, USA. Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Omernik, J.M. 1997. Level III-Level IV ecoregions of Montana. Unpublished First Draft. August, 1997.

Patterson, A.J. 1996. The effect of recreation on biotic integrity of small streams in Grand Teton National Park. Unpublished Master's Thesis. University of Washington, Seattle, Washington.
Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross and R.M.Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers. Benthic Macroinvertebrates and Fish. EPA 440-4-89-001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Rossano, E.M. 1995. Development of an index of biological integrity for Japanese streams (IBI-J). Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Wisseman, R.W. 1992. Montana rapid bioassessment protocols. Benthic invertebrate studies, 1990. Montana Reference Streams study. Report to the Montana Department of Environmental Quality. Water Quality Bureau. Helena, Montana.

Woods, A.J., Omernik, J. M. Nesser, J.A., Shelden, J., and Azevedo, S. H. 1999. Ecoregions of Montana. *(Poster).* Reston, Virginia. USGS.

APPENDIX

Taxonomic data and summaries

Spring Creek, Teton County, Montana

August 1, 2000

Aquatic Invertebrate Taxonomic Data

Site Name: Spring Creek
Site ID: S1 8/1/01

Approx. percent of sample used: 7

Taxon	Quantity	Percent	HBI	FFG
Nematoda	11	3.42	5	PA
Limnodrilus hoffmeisteri	5	1.55	9	CG
Sphaeriidae	50	15.53	8	CG
Fossaria sp.	2	0.62	6	CG
Physidae	13	4.04	8	CG
Ostracoda	24	7.45	8	CG
Acari	7	2.17	5	PA
Total Misc. Taxa	**112**	**34.78**		
Baetis tricaudatus	44	13.66	6	CG
Fallceon quilleri	16	4.97	4	CG
Labiobaetis sp.	3	0.93	4	CG
Ephemerella inermis	2	0.62	1	CG
Paraleptophlebia temporalis	3	0.93	4	CG
Total Ephemeroptera	**68**	**21.12**		
Amphinemura sp.	5	1.55	2	SH
Total Plecoptera	**5**	**1.55**		
Hydroptila sp.	1	0.31	6	PH
Psychoglypha subborealis	2	0.62	2	OM
Rhyacophila Brunnea Gr.	1	0.31	1	PR
Total Trichoptera	**4**	**1.24**		
Dytiscidae - larvae	10	3.11	5	PR
Nebrioporus sp.	12	3.73	5	PR
Optioservus sp.	3	0.93	4	SC
Brychius sp.	1	0.31	5	MH
Hydrophilidae - larvae	1	0.31	5	PR
Total Coleoptera	**27**	**8.39**		
Ceratopogoninae	1	0.31	6	PR
Dixa sp.	1	0.31	2	CG
Simulium sp.	30	9.32	6	CF
Caloparyphus sp.	1	0.31	8	CG
Dicranota sp.	2	0.62	3	PR
Total Diptera	**35**	**10.87**		
Corynoneura sp.	1	0.31	7	CG
Eukiefferiella Pseudomontana Gr.	1	0.31	8	OM
Odontomesa sp.	2	0.62	4	CG
Pagastia sp.	4	1.24	1	CG
Psectrocladius sp.	1	0.31	8	CG
Radotanypus sp.	1	0.31	4	PR
Tanytarsus sp.	51	15.84	6	CF
Thienemanniella sp.	2	0.62	6	CG
Thienemannimyia Gr.	1	0.31	6	PR
Tvetenia sp.	7	2.17	5	CG
Total Chironomidae	**71**	**22.05**		
Grand Total	**322**	**100.00**		

Aquatic Invertebrate Taxonomic Data

Site Name: Spring Creek
Site ID: S3

Approx. percent of sample used: 20

Taxon	Quantity	Percent	HBI	FFG
Polycelis coronata	2	0.65	4	CG
Tubificidae - immature	9	2.91	9	CG
Eiseniella tetraedra	2	0.65	8	CG
Eclipidrilus sp.	2	0.65	8	CG
Sphaeriidae	6	1.94	8	CG
Physidae	8	2.59	8	CG
Gammarus sp.	31	10.03	6	CG
Hyalella azteca	58	18.77	8	CG
Acari	3	0.97	5	PA
Total Misc. Taxa	**121**	**39.16**		
Octogomphus sp.	1	0.32	4	PR
Total Odonata	**1**	**0.32**		
Fallceon quilleri	8	2.59	4	CG
Labiobaetis sp.	5	1.62	4	CG
Caenis latipennis	78	25.24	7	CG
Stenonema sp.	1	0.32	5	SC
Paraleptophlebia sp.	1	0.32	4	CG
Total Ephemeroptera	**93**	**30.10**		
Amphinemura sp.	2	0.65	2	SH
Total Plecoptera	**2**	**0.65**		
Corixidae - immature	11	3.56	8	UN
Total Hemiptera	**11**	**3.56**		
Sialis sp.	1	0.32	4	PR
Total Megaloptera	**1**	**0.32**		
Hydropsychidae - early instars	1	0.32	4	CF
Hydroptila sp.	8	2.59	6	PH
Ithytrichia sp.	1	0.32	6	SC
Lepidostoma sp.-turret case larvae	3	0.97	2	SH
Oecetis sp.	1	0.32	8	OM
Total Trichoptera	**14**	**4.53**		
Dubiraphia sp.	4	1.29	6	CG
Optioservus sp.	51	16.50	4	SC
Total Coleoptera	**55**	**17.80**		
Ceratopogoninae	3	0.97	6	PR
Total Diptera	**3**	**0.97**		
Brillia sp.	1	0.32	5	SH
Microtendipes sp.	1	0.32	6	CG
Phaenopsectra sp.	1	0.32	7	SC
Thienemannimyia Gr.	5	1.62	6	PR
Total Chironomidae	**8**	**2.59**		
Grand Total	**309**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Spring Creek **Site ID: S1 8/1/01**

TOTAL ABUNDANCE	322
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	77
TOTAL NUMBER OF TAXA	36
Number EPT taxa	9

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	7	112	34.78
Odonata	0	0	0.00
Ephemeroptera	5	68	21.12
Plecoptera	1	5	1.55
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	3	4	1.24
Lepidoptera	0	0	0.00
Coleoptera	5	27	8.39
Diptera	5	35	10.87
Chironomidae	10	71	22.05

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.08

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	8	29	9.01
Parasite	2	18	5.59
Collector-gatherer	18	181	56.21
Collector-filterer	2	81	25.16
Macrophyte-herbivore	1	1	0.31
Piercer-herbivore	1	1	0.31
Scraper	1	3	0.93
Shredder	1	5	1.55
Xylophage	0	0	0.00
Omnivore	2	3	0.93
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.04
Scraper/(Scraper + C.filterer)	0.04
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Tanytarsus sp.	51	15.84
Sphaeriidae	50	15.53
Baetis tricaudatus	44	13.66
Simulium sp.	30	9.32
Ostracoda	24	7.45
SUBTOTAL 5 DOMINANTS	199	61.8
Fallceon quilleri	16	4.97
Physidae	13	4.04
Nebrioporus sp.	12	3.73
Nematoda	11	3.42
Dytiscidae - larvae	10	3.11
TOTAL DOMINANTS	261	81.05

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.06

DIVERSITY MEASURES

Shannon H (loge)	2.42
Shannon H (log2)	3.49
Evenness	0.68
Simpson D	0.08

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	143	44.49
Univoltine	126	39.21
Semivoltine	53	16.30

	#TAXA	ABUNDANCE	PERCENT
Tolerant	11	89	27.64
Intolerant	0	0	0.00
Clinger	6	88	27.33

Aquatic Invertebrate Summary Data

Site Name: Spring Creek

Site ID: S3 8/1/00

TOTAL ABUNDANCE	309
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	109
TOTAL NUMBER OF TAXA	30
Number EPT taxa	11

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	9	121	39.16
Odonata	1	1	0.32
Ephemeroptera	5	93	30.10
Plecoptera	1	2	0.65
Hemiptera	1	11	3.56
Megaloptera	1	1	0.32
Trichoptera	5	14	4.53
Lepidoptera	0	0	0.00
Coleoptera	2	55	17.80
Diptera	1	3	0.97
Chironomidae	4	8	2.59

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	13.63

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	4	10	3.24
Parasite	1	3	0.97
Collector-gatherer	14	215	69.58
Collector-filterer	1	1	0.32
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	1	8	2.59
Scraper	4	54	17.48
Shredder	3	6	1.94
Xylophage	0	0	0.00
Omnivore	1	1	0.32
Unknown	1	11	3.56

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	54.00
Scraper/(Scraper + C.filterer)	0.98
Shredder/Total organisms	0.01

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Caenis latipennis	78	25.24
Hyalella azteca	58	18.77
Optioservus sp.	51	16.50
Gammarus sp.	31	10.03
Corixidae - immature	11	3.56
SUBTOTAL 5 DOMINANTS	229	74.11
Tubificidae - immature	9	2.91
Physidae	8	2.59
Fallceon quilleri	8	2.59
Hydroptila sp.	8	2.59
Sphaeriidae	6	1.94
TOTAL DOMINANTS	268	86.73

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.38

DIVERSITY MEASURES

Shannon H (loge)	2.04
Shannon H (log2)	2.94
Evenness	0.60
Simpson D	0.11

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	28	8.98
Univoltine	222	71.93
Semivoltine	59	19.09

	#TAXA	ABUNDANCE	PERCENT
Tolerant	10	241	77.99
Intolerant	0	0	0.00
Clinger	6	66	21.36